Public Buildings Enhanced Energy Efficiency Program

Investigation Report for
Northland Community & Technical College
East Grand Forks

7/12/2012

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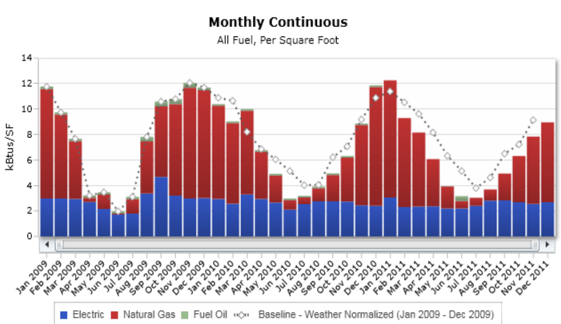
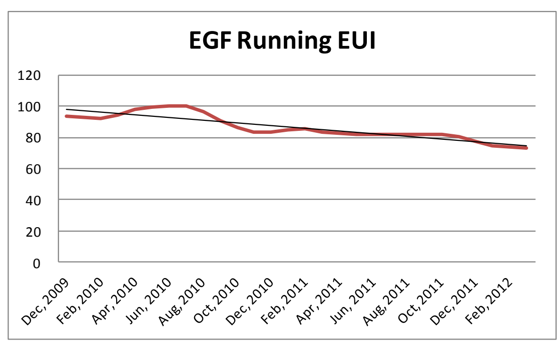
Screening Report

PBEEEP
State Government

The goal of a PBEEEP Energy Investigation is to identify energy savings opportunities with a payback of fifteen years or less. Particular emphasis is on finding those opportunities that will generate savings with a relatively fast (1 to 5 years) and certain payback. During the investigation phase the provider conducts a rigorous analysis of the building operations. Through observation, targeted functional testing, and analysis of extensive trend and portable logger data, the RCx Provider identifies deficiencies in the operation of the mechanical equipment, lighting, envelope, and related controls. The investigation of Northland Community & Technical College East Grand Forks was performed by AMEC Earth and Environmental, Inc. This report is the result of that information.

Payback Information and Energy Savings				
Total Project costs (Without Co-funding)			**Project costs with Co-funding**	
Total costs to date including study	$63,518		Total Project Cost	$85,762
Future costs including Implementation , Measurement & Verification	$22,244		Study and Administrative Cost Paid with ARRA Funds	($66,518)
Total Project Cost	$85,762		Utility Rebates	($0)
			Total costs after co-funding	$19,244
Estimated Annual Total Savings ($)	$1,674		Estimated Annual Total Savings ($)	$1,674
Total Project Payback	51		Total Project Payback with co-funding	11.5
Electric Energy Savings	**1.5 %**	**and**	**Gas Energy Savings**	**0.0 %**





Year	Days	SF	Total kBtu	Normalized Baseline kBtu	Change from Baseline kBtu	% Change	Total Energy Cost $	Average Cost Rate $ /kBtu
2009	365	171,244	16,072,082	16,072,082	0	0%	$169,847.12	$0.01
2010	365	171,244	14,234,309	15,273,154	-1,038,845	-7%	$156,412.49	$0.01
2011	365	171,244	13,299,408	15,787,527	-2,488,119	-16%	$152,326.98	$0.01

The energy use at Northland College East Grand Forks decreased approximately 12% over the period of the investigation.

Admin Minnesota
DEPARTMENT OF ADMINISTRATION

Summary Tables

Facility Name	**Northland Community & Technical College East Grand Forks**
Location	2022 Central Ave NE East Grand Forks MN 56721
Facility Managers	Bob Gooden, Director of Facilities
Number of Buildings Investigated	9
Interior Square Footage Investigated	171,244
PBEEEP Provider	AMEC Earth and Environmental, Inc.
Study Period	October 2011 through April 2012
Annual Energy Cost	$152,327 (2011)
Utility Company	Xcel Energy (Natural Gas) East Grand Forks Water and Lights (Electric)
Site Energy Use Index (EUI)	83 kBtu/sq ft(2010, start of study) 75 kBtu/sq ft(2011/2, end of study)
Benchmark EUI (from B3)	116 kBtu/sq ft

Building Data as listed in B3

Building Name	**State ID**	**Area (Square Feet)**	**Year Built**
Allied Health Addition	E26265T0909	8,412	2009
Classrooms and Offices	E26265T0795	3,080	1995
TD/Carp Add	E26265T0376	16,208	1976
Cabinetry/Storage	E26265T0884	576	1984
Beier Addition	E26265T0484	12,399	1984
Main Bldg	E26265T0174	76,161	1974
75 Addition	E26265T0275	14,188	1975
Health Addition	E26265T0693	34,220	1993
Garage/Storage	E26265T0586	6,000	1986

Mechanical Equipment Included in Investigation: Summary Table	
Total	**Equipment Description**
1	Schneider Electric-IA Building Automation System
9	Buildings
171,244	Interior Square Feet
11	Air Handlers
6	Heating and Ventilating Units
149	VAV Boxes
3	Primary Hot Water Pumps
10	Secondary Hot Water Pumps
3	Hot Water Boilers
2	Primary Chilled Water Pumps
4	Secondary Chilled Water Pumps
1	Air Cooled Chiller
1,850	Approximate number of points available for trending
450	Minimum Points to Trend
50	Data loggers needed to gather data not on BAS (36 for space temperatures, 8 for pumps and 6 for fan status

Implementation Information			
Estimated Annual Total Savings ($)			$1,674
Total Estimated Implementation Cost ($)			$19,244
GHG Avoided in U.S Tons (CO2e)			19
Electric Energy Savings (kWh) (2011 Usage 1,524,677 kWh)		1.5 % Savings	22,533
Gas Energy Savings (Therms) (2011 Usage was 94,180 Therms)		0 % Savings	0
Statistics			
Number of Measures identified			3
Number of Measures with payback < 3 years			0
Screening Start Date	01/20/2011	Screening End Date	04/20/2011
Investigation Start Date	8/19/2011	Investigation End Date	3/16/2012
Final Report	7/11/2012		

Northland Community College, East Grand Forks Cost Information			
Phase		**To date**	**Estimated Future Cost**
Screening		$2,160	
Investigation [Provider]		$55,345	
Investigation [CEE]		$6,013	$1,000
Implementation			$19,244
Implementation [CEE]			$1,000
Measurement & Verification			$1,000
Total		$63,518	$22,244

Co-funding Summary	
Study and Administrative Cost	$66,518
Utility Co-Funding - Estimated Total ($)	$0
Total Co-funding ($)	$66,518

Northland Community & Technical College East Grand Forks Overview

The energy investigation identified 0.5% of total energy savings at Northland Community & Technical College East Grand Forks with measures that payback in less than 15 years and do not adversely affect occupant comfort. The energy savings opportunities identified at Northland Community & Technical College East Grand Forks include upgrading lighting fixtures with more efficient or lower wattage bulbs. The total cost of implementing all the measures is $19,244.

Implementing all these measures can save the facility approximately $1,674 a year. During the period of the PBEEEP investigation energy use at Northland Community & Technical College East Grand Forks decreased approximately 12% compared to the year prior to the study. It is now 35% below the benchmark value according to the Minnesota Benchmarking and Beyond database (B3).

The Northland Community & Technical College East Grand Forks is a 171,244 square foot (sqft) building located in East Grand Forks, MN. The campus is mainly one large building with the boiler plant and carpentry building housed outside the facility. The campus has grown over time; the original building dates from 1974 and there have been 6 additions between 1975 and 2009. There are a total of nine buildings with all of them but the garage/storage and TD/Carpentry addition building being connected together.

Mechanical Equipment

The building contains 3 hot water boilers, one is rated at 2,000 kBtu/hr and the other two are rated at 10,000 kBtu/hr. The 2,000 kBtu/hr boiler can meet the space conditions for 10 months out of the year. These boilers were installed in 2008. The hot water boilers contain 3 primary hot water pumps. The hot water loop consists of two different secondary hot water loops which enter the building at different locations. These two secondary hot water loops contain a total of 10 HWPs, 4 are constant volume and 6 contain VFDs.

There is one 350 ton air cooled chiller which produces chilled water. There are two constant volume primary chilled water pumps. The chiller contains two secondary chilled water loops as well which enter the building at different locations. There are a total of four chilled water pumps associated with these two loops. Two of the pumps are constant volume and two contain VFDs.

There are 11 AHUs and 6 Heating and Ventilating (HV) units which supply conditioned air to spaces within the building. All 11 of the AHUs contain VFDs. Two of the AHUs were installed in 1992 and the remaining 9 are from 2008. There are a total of 149 VAV boxes associated with these AHUs. The 6 HV units serve shop areas and are constant volume for heating only. They are original with the building and from 1973.

Controls and Trending

The building runs on a Schneider Electric-IA automation system. This system controls the majority of mechanical equipment within the complex. The ten secondary HWPs are not on the automation system. The two secondary chilled water pumps which are constant volume are not on the automation system and

HV-6 is not automated as well. The remaining equipment is automated and the system is fully capable of trending any point which needs to be trended. The system can store historical trend data. The AHUs names on the automation system are not the same as they are in the mechanical plans.

Lighting

Indoor lighting- Interior lighting consists of T8 32 watt lamps. A lighting retro-fit was done in 2001. As facility staff moves forward and obtains funding for it they are implementing occupancy sensors to control the indoor lighting. They tie these occupancy sensors into the lights and HVAC system which serves the spaces.

Outdoor lighting- The outdoor lighting around the perimeter of the building are new LED lights, which were installed last year. Lighting along the sidewalks to the building are high pressure sodium lights. These lights are controlled by photocells and timers.

Metering

The building contains one electrical meter, and two natural gas meters.

Findings Summary

Building: Northland College Main Building

Site: Northland CTC E Grand Forks

PBEEEP State Government

Eco #	Investigation Finding	Total Cost	Savings	Payback	Co-Funding	Payback Co-Funding	GHG
4	Incandescent PAR30 lamps being installed.	$1,454	$217	6.70	$0	6.70	3
2	32 Watt T8 Lighting.	$6,512	$633	10.29	$0	10.29	7
1	Efficiency of installed fixtures are much lower than efficiency of currently available fixtures.	$11,278	$824	13.69	$0	13.69	10
	Total for Findings with Payback 3 years or less:	**$0**	**$0**	**0.00**	**$0**	**0.00**	**0**
	Total for all Findings:	**$19,244**	**$1,674**	**11.50**	**$0**	**11.50**	**19**

PBEEEP was made possible with funding from the U.S. Department of Energy
and the MN Department of Commerce.

PBEEEP State Government

Rev. 2.0 (12/16/2010)

15101 - Northland CTC- EGF Main Building

This checklist is designed to be a resource and reference for Providers and PBEEEP.

Finding Category	Finding Type Number	Finding Type	Relevant Findings (if any)	Finding Location	Reason for no relevant finding	Notes
a. Equipment Scheduling and Enabling:	a.1 (1)	Time of Day enabling is excessive			Investigation looked for, but did not find this issue.	
	a.2 (2)	Equipment is enabled regardless of need, or such enabling is excessive			Investigation looked for, but did not find this issue.	
	a.3 (3)	Lighting is on more hours than necessary.			Investigation looked for, but did not find this issue.	
	a.4 (4)	OTHER_Equipment Scheduling/Enabling			Not Relevant	
b. Economizer/Outside Air Loads:	b.1 (5)	Economizer Operation – Inadequate Free Cooling (Damper failed in minimum or closed position, economizer setpoints not optimized)			Investigation looked for, but did not find this issue.	
	b.2 (6)	Over-Ventilation – Outside air damper failed in an open position. Minimum outside air fraction not set to design specifications or occupancy.	X	AHU 3		
	b.3 (7)	OTHER_Economizer/OA Loads			Not Relevant	
c. Controls Problems:	c.1 (8)	Simultaneous Heating and Cooling is present and excessive			Investigation looked for, but did not find this issue.	
	c.2 (9)	Sensor/Thermostat needs calibration, relocation/shielding, and/or replacement			Investigation looked for, but did not find this issue.	
	c.3 (10)	Controls "hunt" and/or need Loop Tuning or separation of heating/cooling setpoints			Not Relevant	
	c.4 (11)	OTHER_Controls			Not Relevant	
d. Controls (Setpoint Changes):	d.1 (12)	Daylighting controls or occupancy sensors need optimization.			Investigation looked for, but did not find this issue.	
	d.2 (13)	Zone setpoint setup/setback are not implemented or are sub-optimal.			Investigation looked for, but did not find this issue.	
	d.3 (14)	Fan Speed Doesn't Vary Sufficiently			Investigation looked for, but did not find this issue.	
	d.4 (15)	Pump Speed Doesn't Vary Sufficiently	X	Mechanical Room		
	d.5 (16)	VAV Box Minimum Flow Setpoint is higher than necessary			Investigation looked for, but did not find this issue.	
	d.6 (17)	Other_Controls (Setpoint Changes)			Not Relevant	
e. Controls (Reset Schedules):	e.1 (18)	HW Supply Temperature Reset is not implemented or is sub-optimal			Investigation looked for, but did not find this issue.	
	e.2 (19)	CHW Supply Temperature Reset is not implemented or is sub-optimal			Investigation looked for, but did not find this issue.	
	e.3 (20)	Supply Air Temperature Reset is not implemented or is sub-optimal			Investigation looked for, but did not find this issue.	
	e.4 ( )	Supply Duct Static Pressure Reset is not implemented or is sub-optimal			Investigation looked for, but did not find this issue.	
	e.5 (21)	Condenser Water Temperature Reset is not implemented or is sub-optimal			Not Relevant	
	e.6 (22)	Other_Controls (Reset Schedules)			Not Relevant	
f. Equipment Efficiency Improvements / Load Reduction:	f.1 (23)	Daylighting Control needs optimization—Spaces are Over-Lit			Investigation looked for, but did not find this issue.	
	f.2 (24)	Pump Discharge Throttled	X	Hot Water Pumps		
	f.3 (25)	Over-Pumping	X	Hot Water Pumps		
	f.4 (26)	Equipment is oversized for load.	X	Hot Water Pumps		
	f.5 (27)	OTHER_Equipment Efficiency/Load Reduction			Not Relevant	
	g.1 (28)	VFD Retrofit - Fans			Investigation looked for, but did not find this issue.	

PBEEEP State Government

Rev. 2.0 (12/16/2010)

15101 - Northland CTC- EGF Main Building

This checklist is designed to be a resource and reference for Providers and PBEEEP.

Finding Category	Finding Type Number	Finding Type	Relevant Findings (if any)	Finding Location	Reason for no relevant finding	Notes
g. Variable Frequency Drives (VFD):	g.2 (29)	VFD Retrofit - Pumps	X	Hot Water Pumps		
	g.3 (30)	VFD Retrofit - Motors (process)			Investigation looked for, but did not find this issue.	
	g.4 (31)	OTHER_VFD			Not Relevant	
h. Retrofits:	h.1 (32)	Retrofit - Motors			Investigation looked for, but did not find this issue.	
	h.2 (33)	Retrofit - Chillers			Investigation looked for, but did not find this issue.	
	h.3 (34)	Retrofit - Air Conditioners (Air Handling Units, Packaged Unitary Equipment)			Investigation looked for, but did not find this issue.	
	h.4 (35)	Retrofit - Boilers			Investigation looked for, but did not find this issue.	
	h.5 (36)	Retrofit - Packaged Gas fired heating			Not Relevant	
	h.6 (37)	Retrofit - Heat Pumps			Not Relevant	
	h.7 (38)	Retrofit - Equipment (custom)			Not Relevant	
	h.8 (39)	Retrofit - Pumping distribution method	X	Hot Water Pumps		
	h.9 (40)	Retrofit - Energy/Heat Recovery			Not cost-effective to investigate	
	h.10 (41)	Retrofit - System (custom)			Not Relevant	
	h.11 (42)	Retrofit - Efficient Lighting	X	Automotive 305, Hallways		Installed 400 watt Metal Halide fixtures in Automotive 305. Install 28 watt fluorescen
	h.12 (43)	Retrofit - Building Envelope			Not Relevant	
	h.13 (44)	Retrofit - Alternative Energy			Not Relevant	
	h.14 (45)	OTHER_Retrofit			Not Relevant	
i. Maintenance Related Problems:	i.1 (46)	Differed Maintenance from Recommended/Standard			Not Relevant	
	i.2 (47)	Impurity/Contamination			Not Relevant	
	i.3 ( )	Leaky/Stuck Damper	X	AHU 3		
	i.4 ( )	Leaky/Stuck Valve			Not Relevant	
	i.5 (48)	OTHER_Maintenance			Not Relevant	
j. OTHER	j.1 (49)	OTHER			Not Relevant	

t lamps in the hallways.

Findings Glossary: Findings Examples

a.1 (1)	**Time of Day enabling is excessive**
	• HVAC running when building is unoccupied. Equipment schedule doesn't follow building occupancy • Optimum start-stop is not implemented • Controls in hand
a.2 (2)	**Equipment is enabled regardless of need, or such enabling is excessive**
	• Fan runs at 2" static pressure. Lowering pressure to 1.8" does not create comfort problem and the flow is per design. • Supply air temperature and pressure reset: cooling and heating
a.3 (3)	**Lighting is on more hours than necessary**
	• Lighting is on at night when the building is unoccupied • Photocells could be used to control exterior lighting • Lighting controls not calibrated/adjusted properly
a.4 (4)	**OTHER Equipment Scheduling and Enabling**
	• Please contact PBEEEP Project Engineer for approval
b.1 (5)	**Economizer Operation – Inadequate Free Cooling**
	• Economizer is locked out whenever mechanical cooling is enabled (non-integrated economizer) • Economizer linkage is broken • Economizer setpoints could be optimized • Plywood used as the outdoor air control • Damper failed in minimum or closed position
b.2 (6)	**Over-Ventilation**
	• Demand-based ventilation control has been disabled • Outside air damper failed in an open position • Minimum outside air fraction not set to design specifications or occupancy
b.3 (7)	**OTHER Economizer/Outside Air Loads**
	• Please contact PBEEEP Project Engineer for approval
c.1 (8)	**Simultaneous Heating and Cooling is present and excessive**
	• For a given zone, CHW and HW systems are unnecessarily on and running simultaneously • Different setpoints are used for two systems serving a common zone
c.2 (9)	**Sensor / Thermostat needs calibration, relocation / shielding, and/or replacement**
	• OAT temperature is reading 5 degrees high, resulting in loss of useful economizer operation • Zone sensors need to be relocated after tenant improvements • OAT sensor reads high in sunlight
c.3 (10)	**Controls "hunt" / need Loop Tuning or separation of heating/cooling setpoints**
	• CHW valve cycles open and closed • System needs loop tuning – it is cycling between heating and cooling
c.4 (11)	**OTHER Controls**
	• Please contact PBEEEP Project Engineer for approval
d.1 (12)	**Daylighting controls or occupancy sensors need optimization**
	• Existing controls are not functioning or overridden • Light sensors improperly placed or out of calibration
d.2 (13)	**Zone setpoint setup / setback are not implemented or are sub-optimal**
	• The cooling setpoint is 74 ºF 24 hours per day
d.3 (14)	**Fan Speed Doesn't Vary Sufficiently**
	• Fan runs at 2" static pressure. Lowering pressure to 1.8" does not create comfort problem and the flow is per design. • Supply air temperature and pressure reset: cooling and heating

d.4 (15)	**Pump Speed Doesn't Vary Sufficiently**	
		• Pump runs at 15 PSI on peak day. Lowering pressure to 12 does not create comfort problem and the flow is per design. Low ΔT across the chiller during low load conditions.
d.5 (16)	**VAV Box Minimum Flow Setpoint is higher than necessary**	
		• Boxes universally set at 40%, regardless of occupancy. Most boxes can have setpoints lowered and still meet minimum airflow requirements.
d.6 (17)	**Other Controls (Setpoint Changes)**	
		• Please contact PBEEEP Project Engineer for approval
e.1 (18)	**HW Supply Temperature Reset is not implemented or is sub-optimal**	
		• HW supply temperature is a constant 180 ºF. It should be reset based on demand, or decreased by a reset schedule as OAT increases. • DHW Setpoints are constant 24 hours per day
e.2 (19)	**CHW Supply Temperature Reset is not implemented or is sub-optimal**	
		• CHW supply temperature is a constant 42 ºF. It could be reset, based on demand or ambient temperature.
e.3 (20)	**Supply Air Temperature Reset is not implemented or is sub-optimal**	
		• The SAT is constant at 55 ºF. It could be reset to minimize reheat and maximize economizer cooling. The reset should ideally be based on demand (e.g., looking at zone box damper positions), but could also be reset based on OAT.
e.4 ( )	**Supply Duct Static Pressure Reset is not implemented or is suboptimal**	
		• The Duct Static Pressure (DSP) is constant at 1.5" wc. It could be reset to minimize fan energy. The reset should ideally be based on demand (e.g. looking at zone box damper positions), but could also be reset based on OAT.
e.5 (21)	**Condenser Water Temperature Reset is not implemented or is sub-optimal**	
		• CW temperature is constant leaving the tower at 85 ºF. The temperature should be reduced to minimize the total energy use of the chiller and tower. It may be worthwhile to reset based on load and ambient conditions.
e.6 (22)	**Other Controls (Reset Schedules)**	
		• Please contact PBEEEP Project Engineer for approval
f.1 (23)	**Lighting system needs optimization - Spaces are overlit**	
		• Lighting exceeds ASHRAE or IES standard levels for specific space types or tasks
f.2 (24)	**Pump Discharge Throttled**	
		• The discharge valve for the CHW pump is 30% open. The valve should be opened and the impeller size reduced to provide the proper flow without throttling.
f.3 (25)	**Over-Pumping**	
		• Only one CHW pump runs when one chiller is running. However, due to the reduced pressure drop in the common piping, the pump is providing much greater flow than needed.
f.4 (26)	**Equipment is oversized for load**	
		• The equipment cycles unnecessarily • The peak load is much less than the installed equipment capacity

f.5 (27)	**OTHER Equipment Efficiency/Load Reduction**	
		• Please contact PBEEEP Project Engineer for approval
g.1 (28)	**VFD Retrofit Fans**	
		• Fan serves variable flow system, but does not have a VFD. • VFD is in override mode, and was found to be not modulating.
g.2 (29)	**VFD Retrofit - Pumps**	
		• 3-way valves are used to maintain constant flow during low load periods. • Only one CHW pumps runs when one chiller is running. However, due to the reduced pressure drop in the common piping, the pump is providing much greater flow than needed.
g.3 (30)	**VFD Retrofit - Motors (process)**	
		• Motor is constant speed and uses a variable pitch sheave to obtain speed control.
g.4 (31)	**OTHER VFD**	
		• Please contact PBEEEP Project Engineer for approval
h.1 (32)	**Retrofit - Motors**	
		• Efficiency of installed motor is much lower than efficiency of currently available motors
h.2 (33)	**Retrofit - Chillers**	
		• Efficiency of installed chiller is much lower than efficiency of currently available chillers
h.3 (34)	**Retrofit - Air Conditioners (Air Handling Units, Packaged Unitary Equipment)**	
		• Efficiency of installed air conditioner is much lower than efficiency of currently available air conditioners
h.4 (35)	**Retrofit - Boilers**	
		• Efficiency of installed boiler is much lower than efficiency of currently available boilers
h.5 (36)	**Retrofit - Packaged Gas-fired heating**	
		• Efficiency of installed heaters is much lower than efficiency of currently available heaters
h.6 (37)	**Retrofit - Heat Pumps**	
		• Efficiency of installed heat pump is much lower than efficiency of currently available heat pumps
h.7 (38)	**Retrofit - Equipment (custom)**	
		• Efficiency of installed equipment is much lower than efficiency of currently available equipment
h.8 (39)	**Retrofit - Pumping distribution method**	
		• Current pumping distribution system is inefficient, and could be optimized. • Pump distribution loop can be converted from primary to primary-secondary)
h.9 (40)	**Retrofit - Energy / Heat Recovery**	
		• Energy is not recouped from the exhaust air. • Identification of equipment with higher effectiveness than the current equipment.
h.10 (41)	**Retrofit - System (custom)**	
		• Efficiency of installed system is much lower than efficiency of another type of system
h.11 (42)	**Retrofit - Efficient lighting**	
		• Efficiency of installed lamps, ballasts or fixtures are much lower than efficiency of currently available lamps, ballasts or fixtures.

h.12 (43)	**Retrofit - Building Envelope**	
		• Insulation is missing or insufficient • Window glazing is inadequate • Too much air leakage into / out of the building • Mechanical systems operate during unoccupied periods in extreme weather
h.13 (44)	**Retrofit - Alternative Energy**	
		• Alternative energy strategies, such as passive/active solar, wind, ground sheltered construction or other alternative, can be incorporated into the building design
h.14 (45)	**OTHER Retrofit**	
		• Please contact PBEEEP Project Engineer for approval
i.1 (46)	**Differed Maintenance from Recommended/Standard**	
		• Differed maintenance that results in sub-optimal energy performance. • Examples: Scale buildup on heat exchanger, broken linkages to control actuator missing equipment components, etc.
i.2 (47)	**Impurity/Contamination**	
		• Impurities or contamination of operating fluids that result in sub-optimal performance. Examples include lack of chemical treatment to hot/cold water systems that result in elevated levels of TDS which affect energy efficiency.
i.3 ( )	**Leaky/Stuck Damper**	
		• The outside or return air damper on an AHU is leaking or is not modulating causing the energy use go up because of additional load to the central heating and/or cooling plant.
i.4 ( )	**Leaky/Stuck Valve**	
		• The heating or cooling coil valve on an AHU is leaking or is not modulating causing the energy use go up because of additional load to the central heating and/or cooling plant.
i.5 (48)	**OTHER Maintenance**	
		• Please contact PBEEEP Project Engineer for approval
j.1 (49)	**OTHER**	
		• Please contact PBEEEP Project Engineer for approval

Findings Details

PBEEEP State Government

Building: Northland College Main Building

FWB Number:	15101	Eco Number:	1
Site:	Northland CTC E Grand Forks	Date/Time Created:	7/10/2012

Investigation Finding:	Efficiency of installed fixtures are much lower than efficiency of currently available fixtures.	Date Identified:	1/2/2012
Description of Finding:	400 watt metal halide fixtures were found in the Automotive Room 305. Energy efficient upgrades could be performed to save energy.		
Equipment or System(s):	Interior Lighting	Finding Category:	Retrofits
Finding Type:	Retrofit - Efficient Lighting		

Implementer:	Lighting contractor.	Benefits:	Energy savings and load reduction.
Baseline Documentation Method:	Visual inspection of the lamps concluded 400 watt metal halide fixtures are being installed.		
Measure:	Replace 400 watt metal halide lamps with 6 lamp T8 fixtures.		
Recommendation for Implementation:	Replace 400 watt metal halide lamps with 6 lamp T8 fixtures.		
Evidence of Implementation Method:	Visually inspect and submit photo and invoice of the 6 lamp T8 fixtures.		

Annual Electric Savings (kWh):	11,092	Contractor Cost ($):	$10,918
Estimated Annual kWh Savings ($):	$824	PBEEEP Provider Cost for Implementation Assistance ($):	$360
		Total Estimated Implementation Cost ($):	$11,278

Estimated Annual Total Savings ($):	$824	Utility Co-Funding for kWh ($):	$0
Initial Simple Payback (years):	13.69	Utility Co-Funding for kW ($):	$0
Simple Payback w/ Utility Co-Funding (years):	13.69	Utility Co-Funding for therms ($):	$0
GHG Avoided in U.S. Tons (C02e):	10	Utility Co-Funding - Estimated Total ($):	$0

Current Project as Percentage of Total project			
Percent Savings (Costs basis)	49.2%	Percent of Implementation Costs:	58.6%

Findings Details

Building: Northland College Main Building

FWB Number:	15101	Eco Number:	2
Site:	Northland CTC E Grand Forks	Date/Time Created:	7/10/2012

Investigation Finding:	32 Watt T8 Lighting.	Date Identified:	2/16/2012
Description of Finding:	32 Watt T8 Lamps were found throughout the hallways. There are more energy efficient lights available.		
Equipment or System(s):	Interior Lighting	Finding Category:	Retrofits
Finding Type:	Retrofit - Efficient Lighting		

Implementer:	Lighting contractor	Benefits:	Energy savings and load reduction
Baseline Documentation Method:	Visual inspection of the lamps concluded 32 watt T8 lamps are being installed.		
Measure:	Replace 32 watt lamps with 28 watt lamps.		
Recommendation for Implementation:	Replace the 32 watt T8 lamps with 28 watt T8 lamps throughout the hallways.		
Evidence of Implementation Method:	Visually inspect the lamps to ensure 28 watt T8 lamps are being installed. Submit invoice showing the lamps were purchased with pictures of the lamps installed.		

Annual Electric Savings (kWh):	8,520	Contractor Cost ($):	$6,152
Estimated Annual kWh Savings ($):	$633	PBEEEP Provider Cost for Implementation Assistance ($):	$360
		Total Estimated Implementation Cost ($):	$6,512

Estimated Annual Total Savings ($):	$633	Utility Co-Funding for kWh ($):	$0
Initial Simple Payback (years):	10.29	Utility Co-Funding for kW ($):	$0
Simple Payback w/ Utility Co-Funding (years):	10.29	Utility Co-Funding for therms ($):	$0
GHG Avoided in U.S. Tons (C02e):	7	Utility Co-Funding - Estimated Total ($):	$0

Current Project as Percentage of Total project			
Percent Savings (Costs basis)	37.8%	Percent of Implementation Costs:	33.8%

Findings Details

Building: Northland College Main Building

FWB Number:	15101	Eco Number:	4
Site:	Northland CTC E Grand Forks	Date/Time Created:	7/10/2012

Investigation Finding:	Incandescent PAR30 lamps being installed.	Date Identified:	2/16/2012
Description of Finding:	Incandescent PAR30 lamps are being installed in the Bookstore and are used as spot lighting for the merchandise.		
Equipment or System(s):	Interior Lighting	Finding Category:	Retrofits
Finding Type:	Retrofit - Efficient Lighting		

Implementer:	Lighting contractor	Benefits:	Energy savings and load reduction
Baseline Documentation Method:	Visual inspection of the lamps concluded incandescent PAR30 lamps are being installed.		
Measure:	Replace incandescent PAR30 lamps with 16 watt CFL PAR30 lamps		
Recommendation for Implementation:	Replace the incandescent PAR30 lamps with 16 watt CFL PAR30 lamps throughout the Bookstore.		
Evidence of Implementation Method:	Visually inspect the lamps to ensure 16 watt PAR30 lamps are being installed. Submit invoice showing the lamps were purchased.		

Annual Electric Savings (kWh):	2,921	Contractor Cost ($):	$1,094
Estimated Annual kWh Savings ($):	$217	PBEEEP Provider Cost for Implementation Assistance ($):	$360
		Total Estimated Implementation Cost ($):	$1,454

Estimated Annual Total Savings ($):	$217	Utility Co-Funding for kWh ($):	$0
Initial Simple Payback (years):	6.70	Utility Co-Funding for kW ($):	$0
Simple Payback w/ Utility Co-Funding (years):	6.70	Utility Co-Funding for therms ($):	$0
GHG Avoided in U.S. Tons (C02e):	3	Utility Co-Funding - Estimated Total ($):	$0

Current Project as Percentage of Total project			
Percent Savings (Costs basis)	13.0%	Percent of Implementation Costs:	7.6%

Northland Community College, East Grand Forks

Deleted Findings Report

FWB Number:	15101	Eco #: 3	Building: Northland College Main Building
Investigation Finding:	32 Watt T8 Lighting.	Equipment or System(s):	Interior Lighting
Measure:	Replace 32 watt lamps with 28 watt lamps. Total cost of $955 with an annual savings of $38 for a 25 year payback.		

FWB Number:	15101	Eco #: 5	Building: Northland College Main Building
Investigation Finding:	Stuck outside air damper for an air handling unit.	Equipment or System(s):	AHU with heating and cooling
Measure:	Fix the damper control to allow for proper operation of the outside air damper.		

FWB Number:	15101	Eco #: 6	Building: Northland College Main Building
Investigation Finding:	Pump speed doesn't vary sufficiently.	Equipment or System(s):	Pump, HW distribution
Measure:	Replace existing three way hot water valves on AHU 1, 2, 3, 4, 5, 7, 8, 9, 10 and 11 and HV 1, 3, 4, 5 and 6 with two way valves. Total cost of $25,431 with savings of 32,296 kWh/yr for a 12 year payback.		

PBEEEP
State Government

Public Buildings Enhanced Energy Efficiency Program

SCREENING RESULTS FOR NORTHLAND COMMUNITY AND TECHNICAL COLLEGE EAST GRAND FORKS

NORTHLAND
COMMUNITY & TECHNICAL COLLEGE

April 20, 2011

Summary Table

Northland Community & Technical College East Grand Forks	
Location	2022 Central Ave NE East Grand Forks MN 56721
Facility Manager	Bob Gooden, Director of Facilities
Number of Buildings	9
Interior Square Footage	171,244
PBEEEP Provider	Center for Energy and Environment (Neal Ray)
Date Visited	January 20, 2011
Annual Energy Cost (from B3)	$163,514.74 (August 2009-August 2010)
Utility Company	Xcel Energy (Natural Gas) East Grand Forks Water and Lights (Electric)
Site Energy Use Index (from B3)	107 kBtu/sq ft(2009)
Benchmark EUI (from B3)	116 kBtu/sq ft

Screening Overview

The goal of screening is to select buildings where an in-depth energy investigation can be performed to identify energy savings opportunities that will generate savings with a relatively short (1 to 5 years) and certain payback. The screening of Northland Community & Technical College East Grand Forks was performed by the Center for Energy and Environment (CEE) with the assistance of the facility staff. A walk-through was conducted on January 20, 2011 and interviews with the facility staff were carried out to fully explore the status of the energy consuming equipment and their potential for recommissioning. This report is the result of that information.

The Northland Community & Technical College East Grand Forks is a 171,244 square foot (sqft) building located in East Grand Forks, MN. The campus is mainly one large building with the boiler plant and carpentry building housed outside the facility. The campus has grown over time; the original building dates from 1974 and there have been 6 additions between 1975 and 2009. There are a total of nine buildings with all of them but the garage/storage and TD/Carpentry addition building being connected together.

Recommendation for Investigation

Northland Community & Technical College East Grand Forks is currently recommended for an investigation. There has been a large amount of mechanical renovation, and it appears that a systematic investigation of the entire facility as a single unit would be beneficial, especially with respect to the controls system.

Building Name	State ID	Square Footage	Year Built
Allied Health Addition	E26265T0909	8,412	2009
Classrooms and Offices	E26265T0795	3,080	1995
TD/Carp Add	E26265T0376	16,208	1976
Cabinetry/Storage	E26265T0884	576	1984
Beier Addition	E26265T0484	12,399	1984
Main Bldg	E26265T0174	76,161	1974
75 Addition	E26265T0275	14,188	1975
Health Addition	E26265T0693	34,220	1993
Garage/Storage	E26265T0586	6,000	1986

Building Overview Section

Mechanical Equipment

The building contains 3 hot water boilers, one is rated at 2,000 kBtu/hr and the other two are rated at 10,000 kBtu/hr. The 2,000 kBtu/hr boiler can meet the space conditions for 10 months out of the year. These boilers were installed in 2008. The hot water boilers contain 3 primary hot water pumps. The hot water loop consists of two different secondary hot water loops which enter the building at different locations. These two secondary hot water loops contain a total of 10 HWPs, 4 are constant volume and 6 contain VFDs.

There is one 350 ton air cooled chiller which produces chilled water. There are two constant volume primary chilled water pumps. The chiller contains two secondary chilled water loops as well which enter the building at different locations. There are a total of four chilled water pumps associated with these two loops. Two of the pumps are constant volume and two contain VFDs.

There are 11 AHUs and 6 Heating and Ventilating (HV) units which supply conditioned air to spaces within the building. All 11 of the AHUs contain VFDs. Two of the AHUs were installed in 1992 and the remaining 9 are from 2008. There are a total of 149 VAV boxes associated with these AHUs. The 6 HV units serve shop areas and are constant volume for heating only. They are original with the building and from 1973.

The following table lists the key mechanical equipment at the facility.

Mechanical Equipment Summary Table	
Quantity	**Equipment Description**
1	Schneider Electric-IA Building Automation System
9	Buildings
171,244	Interior Square Feet
11	Air Handlers
6	Heating and Ventilating Units
149	VAV Boxes
3	Primary Hot Water Pumps
10	Secondary Hot Water Pumps
3	Hot Water Boilers
2	Primary Chilled Water Pumps
4	Secondary Chilled Water Pumps
1	Air Cooled Chiller
750	Approximate number of points for trending

Controls and Trending

The building runs on a Schneider Electric-IA automation system. This system controls the majority of mechanical equipment within the complex. The ten secondary HWPs are not on the automation system. The two secondary chilled water pumps which are constant volume are not on the automation system and HV-6 is not automated as well. The remaining equipment is automated and the system is fully capable of trending any point which needs to be trended. The system can store historical trend data. The AHUs names on the automation system are not the same as they are in the mechanical plans. The tables below describe the correspondence between the automation system and the plans.

Lighting

Indoor lighting- Interior lighting consists of T8 32 watt lamps. A lighting retro-fit was done in 2001. As facility staff moves forward and obtains funding for it they are implementing occupancy sensors to control the indoor lighting. They tie these occupancy sensors into the lights and HVAC system which serves the spaces.

Outdoor lighting- The outdoor lighting around the perimeter of the building are new LED lights, which were installed last year. Lighting along the sidewalks to the building are high pressure sodium lights. These lights are controlled by photocells and timers. .

Energy Use Index B3 Benchmark

The site Energy Use Index (EUI) for the building is 107 kBtu/sqft, which is 8% lower than the B3 Benchmark of 116 kBtu/sqft. The site EUIs for State of Minnesota buildings are 23% lower than their corresponding B3 Benchmarks on average.

Metering

The building contains one electrical meter, and two natural gas meters.

Documentation

The building has plans for every construction process which has been performed on it and they are nicely organized in a file cabinet. All other documentation such as operation and maintenance manuals, control specifications, testing and balancing reports and commissioning reports are not organized and would take some more time to locate the appropriate documentation.

Occupancy

The school is primarily open from 8 AM to 8 PM Monday through Thursday and 8 AM to 5 PM on Friday. These hours are for the fall and spring semesters on the campus. The fall semester runs from approximately August 22nd to December 21st. The spring semester usual runs from approximately January 10 to May 12th. There is also a summer schedule for the campus where the building is on reduced hours. The summer semester runs from approximately May 23rd to August 5th. Staff state they try to schedule mechanical equipment according to how spaces are occupied.

Additional Information form Occupants Interviews and Observations

The following information **has not been** **verified** and was obtained through occupant interviews and/or general observations by the PBEEEP Screening team. This information is provided for reference only:

- This building just recently underwent a large mechanical equipment renovation in 2008. Nine AHUs were replaced, the boilers and chiller were relocated from their original mechanical rooms to a storage shed outside the main building. HW and CHW piping was then run from the storage shed to the main building.
- There was a lighting upgrade done in 2001 changing T12 lights to T8 32 watt lights.
- The lights outside the building were recently upgraded to LED lights.
- There are currently 6 HWPs and 2 CHWPs which are not utilizing their VFDs because they are not on the automation system.
- Building management is currently in the process of installing motion sensors to control lights within the building. These sensors are being tied into the automation system to control the space temperature as well.
- The new AHUs installed in 2008 were tested and balanced and there is a report available for it.

Reasons for Recommending

This screening report is based on the PBEEEP Guidelines. It is based on one site visit, review of the facility documentation, building automation system, a limited inspection of the facility and interviews with the staff. The purpose of the screening report is to evaluate the potential of the facility for the implementation of cost-effective energy efficiency savings through recommissioning. To the best of our knowledge the information here is accurate. It provides a high level view of many of the important parameters of the mechanical equipment in the facility. Because it is the result of a limited audit survey of the facility, it may not be completely accurate or inclusive.

Areas to investigate for further savings

Currently the new HWPs and CHWPs which were installed in the old boiler room were installed with VFDs; however staff cannot utilize the VFDs for several reasons:

- The system is not automated (there is no control of the pumps)
- Three way valves are installed out in the mechanical equipment, not by the pumps.

Right now the staff must run one pump all the time at 100% and the backup pump remains off. The potential of automating the pumps (Heating Library Reheat Pump, Heating Main Reheat Pump #1 and 2, Heating tunnel radiation pump, Heating AHU coil pump #1 and 2, and Chilled water pump #1 and 2) and utilizing the VFDs should be looked at. These pumps would rarely run at 100% if the VFDs were utilized.

Staff stated they are aware of this and are looking into the possibilities of addressing it.

Building Summary Table

The following tables are based on information gathered from interviews with facility staff, a building walk-through, automation system screen-captures, and equipment documentation. The purpose of the tables is to provide the size and quantity of equipment and the level of control present in each building. It is complete and accurate to the best of our knowledge.

Northland Community & Technical College East Grand Forks					
Area (sqft)	171,244	Year Built	1974, 1975, 1976, 1984, 1986, 1993, 1995, 2009	Occupancy (hrs/yr)	4,368
HVAC Equipment					

Description	Type	Size	Notes
AHU-1	Variable air volume	15,200 CFM 25 HP SF	Labeled AC-1 North Admin on the automation system. Contains a VFD
AHU-2	Variable air volume	22,700 CFM 30HP SF	Labeled AC-2 South Admin on the automation system. Contains a VFD
AHU-3	Variable air volume	10,235 CFM 10 HPSF	Labeled AC-1 East on the automation system. Contains a VFD
AHU-4	Variable air volume	5,000 CFM 7.5 HP SF	Labeled AHU Kitchen on the automation system. Contains a VFD
AHU-5		4,680 CFM 5 HP SF	
AHU-6	Variable air volume	8,000 CFM 7.5 HP	Labeled AHU-2 1992 on the automation system. Contains a VFD. Contains a HWP for HW coil
AHU-7	Variable air volume	34,000 CFM 30 HP SF	Labeled AC-1 1992 on the automation system. Contains a VFD. Contains a HWP for HW coil
AHU-8	Variable air volume	10,670 CFM 15 HP SF	
AHU-9	Variable air volume	7,510 CFM 15 HP SF	
AHU-10	Variable air volume	6,270 CFM 10 HP SF	

HVAC Equipment (cont)			
Description	**Type**	**Size**	**Notes**
AHU-11	Variable volume	2,495 CFM 5 HP SF 1.5 HP RF	
HV-1	Constant volume	7.5 HP SF	
HV-2	Constant volume	3 HP SF	
HV-3	Constant volume	7.5 HP SF	
HV-4	Constant volume	10 HP SF	
HV-6	Constant volume		
HV-8	Constant volume		
Heating Library Reheat Pump	Variable volume	0.75 HP 26 gpm	Pump contains a VFD, but it is not utilized because pump is not automated and there are three ways valves out in the pipe system
Heating main reheat pump #1 and 2	Variable volume	2 HP 55 gpm	Pumps contain VFDs. They are not utilized because pump is not automated and there are three ways valves out in the pipe system
Heating tunnel radiation pump	Variable volume	1 HP 30 gpm	Pump contains a VFD, but it is not utilized because pump is not automated and there are three ways valves out in the pipe system
Heating AHU coil pump #1 and 2	Variable volume	10 HP 435 gpm	Pumps contain VFDs. They are not utilized because pump is not automated and there are three ways valves out in the pipe system
Chilled water pump #1 and 2	Variable volume	15 HP 346 gpm	Pumps contain VFDs. They are not utilized because pump is not automated and there are three ways valves out in the pipe system. Serves the northeast loop of the building.
CHWP #3 and 4	Constant volume	10 HP	Serves the southeast chilled water loop of the building.
2 HWP radiation pumps	Constant volume	~2 HP	Serves the southeast radiation loop

HVAC Equipment (cont)

Description	Type	Size	Notes
2 boilers	Hot water	10,000 kBtu/hr	Cleaver Brooks, installed in 2008
1 boiler	Hot water	2000 kBtu/hr	Raypak boiler used for summer reheat and during the swing season. This boiler can only not meet the demand in the space for 3 months out of the year.
3 primary HW pumps	Variable volume	30 HP 850 gpm	Units contain VFDs
1 Chiller	Air cooled	350 tons	
2 Primary CHWPs	Constant volume	30 HP 1,200 gpm	Labeled pump 2A and 2B on the automation system.
2 woodshop HWPs	Constant volume	¼ HP	For hot water in the woodshop
149 VAV boxes	Single duct reheat	80 to 3,000 CFM	

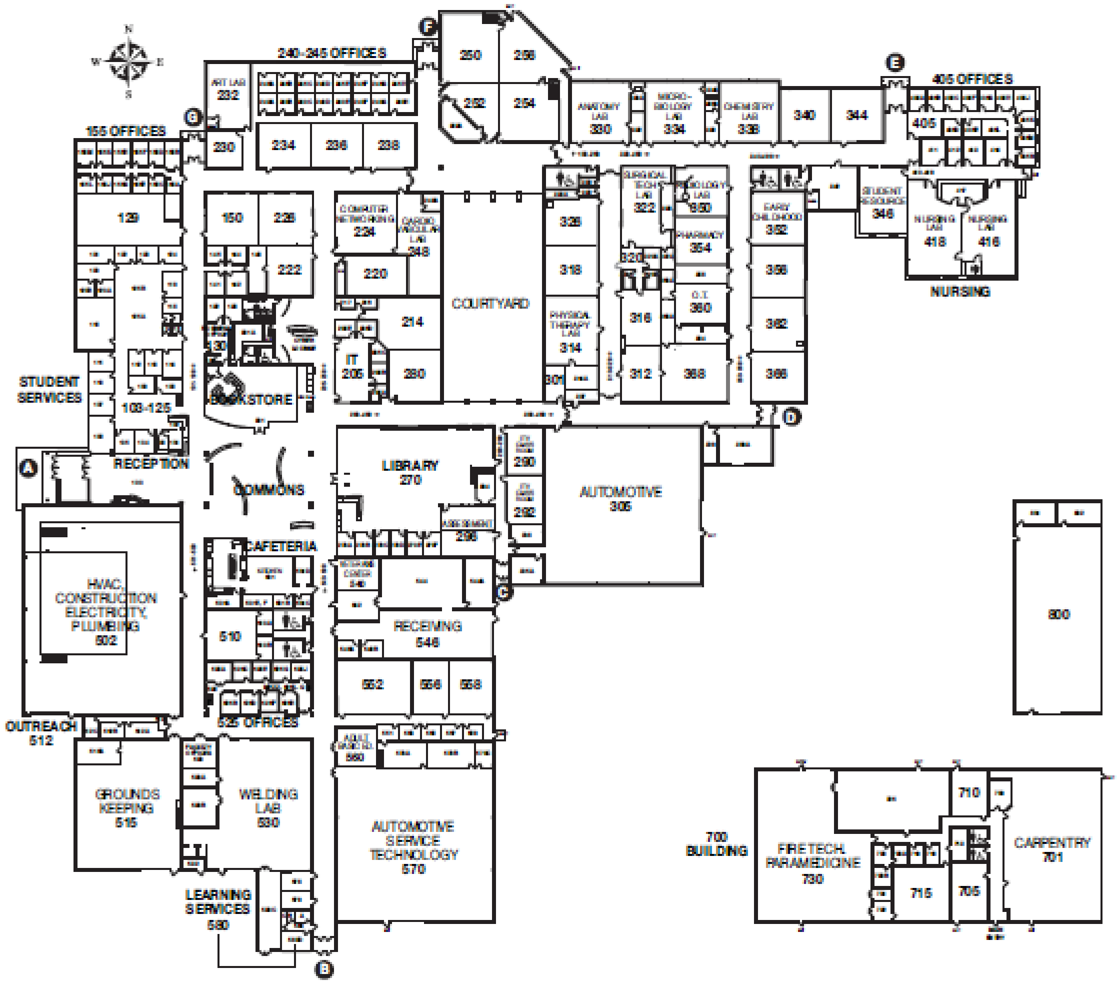
Points on BAS	
Description	**Points**
AC1 North Admin (AHU-1), AC2 South Admin (AHU-2), AC 1 East (AHU-3), AHU2 1992 (AHU-6)	OAT, OA damper %, MAT, CHW valve %, HW valve %, SF command, SF status, SF speed, DAT, Duct static pressure, RAT, RA damper %, Relief damper %, DAT setpoint, MAT setpoint, OA minimum damper position, OA damper lockout setpoint, Night heating setpoint, Night cooling setpoint, Duct static pressure setpoint
AHU Kitchen (AHU-4)	OAT, OA damper %, MAT, CHW valve %, HW valve %, SF command, SF status, SF speed, DAT, Space temperature, Duct static pressure, RAT, RA damper %, Hood status, Space temperature setpoint,, MAT setpoint, OA minimum damper position, OA damper lockout setpoint, Night heating setpoint, Night cooling setpoint, Duct static pressure setpoint
AC3 1973 (AHU-5)	OAT, OA damper %, MAT, CHW valve %, HW valve %, SF command, SF status, SF speed, DAT, Duct static pressure, RAT, RA damper %, DAT setpoint, MAT setpoint, OA minimum damper position, OA damper lockout setpoint, Night heating setpoint, Night cooling setpoint, Duct static pressure setpoint
AC1 1992 (AHU-7)	OAT, OA damper %, MAT, CHW valve %, HW valve %, SF command, SF status, SF speed, DAT, Duct static pressure, RAT, RA damper %, Relief damper %, DAT setpoint, MAT setpoint, OA minimum damper position, OA damper lockout setpoint, Night heating setpoint, Night cooling setpoint, Duct static pressure setpoint, Room 338 temperature, Room 338 radiation pump day setpoint, Room 338 radiation pump night setpoint, Radiation pump command
AHU-8 AHU-9 AHU-10	OAT, OA damper %, MAT, CHW valve %, HW valve %, SF command, SF status, SF speed, DAT, Duct static pressure, RAT, RA damper %, Relief damper %, DAT setpoint, MAT setpoint, OA minimum damper position, OA damper lockout setpoint, Night heating setpoint, Night cooling setpoint, Duct static pressure setpoint, VAV valve override
AC1 1975	OAT, OA damper %, MAT, SF command, SF status, HW valve %, DAT, Space temperature, Relief damper %, Space temperature setpoint, MAT setpoint, OA damper %, OA damper lockout setpoint

Points on BAS

Description	Points
Chiller	Chiller status, Chiller supply temperature, Chiller return temperature, Pump 2 A command, Pump 2A status, Pump 2B command, Pump 2B status, Pump 1A command, Pump 1A status, Pump 1A speed, Pump 1B command, Pump 1B status, Pump 1B speed, CHW differential pressure setpoint, CHWST, CHWRT, Pump 3 command, Pump 3 status, Pump 3 speed, Pump 4 command, Pump 4 status, Pump 4 speed, East side differential pressure setpoint, West side differential pressure setpoint, CHWST setpoint
Boiler system	Boiler #1 status, Boiler #2 status, Boiler #3 status, Pump #1 command, Pump #1 status, Pump #1 speed, Pump #2 command, Pump #2 status, Pump #2 speed, Pump #3 command, Pump #3 status, Pump #3 speed, HWST, HWRT, Max HW temperature differential, Boiler room temperature, Room cooling setpoint, EF OAT setpoint
VAV	Supply air from AHU, Cooling output, Reheat valve %, Space temperature, Box flow, Box flow setpoint, Max flow, Min flow, VAV static pressure, Actual space temperature setpoint Unoccupied cooling setpoint, Unoccupied heating setpoint
CUH	Space temperature, HW valve command, Space temperature setpoint

Building Plans

First Floor



PBEEEP Abbreviation Descriptions			
AHU	Air Handling Unit	HUH	Horizontal Unit Heater
BAS	Building Automation System	HV	Heating and Ventilating Units
CD	Cold Deck	HW	Hot Water
CDW	Condenser Water	HWDP	Hot Water Differential Pressure
CDWRT	Condenser Water Return Temperature	HWP	Hot Water Pump
CDWST	Condenser Water Supply Temperature	HWRT	Hot Water Return Temperature
CFM	Cubic Feet per Minute	HWST	Hot Water Supply Temperature
CHW	Chilled Water	HX	Heat Exchanger
CHWRT	Chilled Water Return Temperature	kW	Kilowatt
CHWDP	Chilled Water Differential Pressure	kWh	Kilowatt-hour
CHWP	Chilled Water Pump	MA	Mixed Air
CHWST	Chilled Water Supply Temperature	MA Enth	Mixed Air Enthalpy
CRAC	Computer Room Air Conditioner	MARH	Mixed Air Relative Humidity
CUH	Cabinet Unit Heater	MAT	Mixed Air Temperature
CV	Constant Volume	MAU	Make-up Air Unit
DA	Discharge Air	OA	Outside Air
DA Enth	Discharge Air Enthalpy	OA Enth	Outside Air Enthalpy
DARH	Discharge Air Relative Humidity	OARH	Outside Air Relative Humidity
DAT	Discharge Air Temperature	OAT	Outside Air Temperature
DDC	Direct Digital Control	Occ	Occupied
DP	Differential Pressure	PTAC	Packaged Terminal Air Conditioner
DSP	Duct Static Pressure	RA	Return Air
DX	Direct Expansion	RA Enth	Return Air Enthalpy
EA	Exhaust Air	RARH	Return Air Relative Humidity
EAT	Exhaust Air Temperature	RAT	Return Air Temperature
Econ	Economizer	RF	Return Fan
EF	Exhaust Fan	RH	Relative Humidity
Enth	Enthalpy	RTU	Rooftop Unit
ERU	Energy Recovery Unit	SF	Supply Fan
FCU	Fan Coil Unit	Unocc	Unoccupied
FPVAV	Fan Powered VAV	UH	Unit Heater
FTR	Fin Tube Radiation	VAV	Variable Air Volume
GPM	Gallons per Minute	VFD	Variable Frequency Drive
HD	Hot Deck	VIGV	Variable Inlet Guide Vanes
HP	Horsepower	VUH	Vertical Unit Heater

Conversions
1 kWh = 3.412 kBtu
1 Therm = 100 kBtu
1 kBtu/hr = 1 MBH